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EXAMINER

BAKER, STEPHEN M

ART UNIT	PAPER NUMBER
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2133

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Please find below and/or attached an Office communication concerning this application or proceeding.

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Office Action Summary

Application No.

09/965,229

Applicant(s)

MADDUX, JOHN T.

Examiner

Stephen M. Baker

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☐ Responsive to communication(s) filed on ____.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-33 is/are pending in the application.
- 4a) Of the above claim(s) ____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) ____ is/are allowed.
- 6) ☒ Claim(s) 1-33 is/are rejected.
- 7) ☐ Claim(s) ____ is/are objected to.
- 8) ☐ Claim(s) ____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☒ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on ____ is/are: a) ☐ accepted or b) ☒ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
 - ☐ Certified copies of the priority documents have been received in Application No. ____.
 - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. ____. |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date ____. | 6) <input type="checkbox"/> Other: ____. |

DETAILED ACTION

Drawings

1. The drawings are objected to because:

In Figs. 4 and 5, the next state variables "s" within the table entries apparently should be "S", to agree with the upper-case convention of current state variables in the row headings.

In Figs. 4 and 5, the sample positions (given only as "d" and a number) in the headings for each column of the tables apparently fail to properly distinguish between same-numbered sample points of different cycles, if a possible correct operation of the invention is understood here, and thus the column headings give an incorrect description of how the invention could be implemented. In Fig. 4, and within each individual cycle of Fig. 5, the sample "d1" in the first edge indicator "d1⊕d2" is presumably not the same "d1" used in "d6⊕d1". This presumption is based on the description's repeated indications that only adjacent samples are compared in the edge detector. Because "d6" and "d1" samples taken in the same cycle, as apparently repeatedly described (with one exception, in paragraph [0020]) in the disclosure, would be non-adjacent, spurious edge detections and edge misses could result when the "d1" sample value in one cycle is not the same for "d1" in the next cycle. The decision matrix's ability to handle missed edges and multiple edges in a single cycle could compensate for the needlessly spurious edge detection implied by much of the disclosure, but there are apparent inconsistencies in the disclosure, nonetheless. It is

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therefor appropriate, to clarify the operation of the invention, that each "d" number should be associated with the correct cycle designation currently not provided by the table headings. The examiner's suggestion here would be to substitute the legend "d1(t-1)" for the "d1" sample in the samples actually taken in the "previous cycle", "d1(t)" for the "d1" sample in the samples actually taken in the "current cycle", and so on for every sample point shown.

The Fig. 2 apparatus apparently, if the examiner's understanding is correct, requires non-described/unshown storage elements and an additional sample output line for presenting seven samples, *i.e.* d1-d6 of one cycle (t-1) together with d1 of the next cycle (t), not six samples as described and shown. The Fig. 2 apparatus has an apparently needless delay -- a full cycle -- inherent in the edge-detection information convention using $d1(t) \oplus d2(t)$ and $d6(t) \oplus d1(t+1)$, instead of $d6(t-1) \oplus d1(t)$ and $d5(t) \oplus d6(t)$, for the first and last edge detections in each cycle. Fig. 2, therefor, does not appear at face value to be a serious attempt to represent a working apparatus.

The Fig. 5 edge detection arrangement, if realized with outputs of a parallel oversampler which is double the width of the parallel oversampler 202 shown in the single-cycle Fig. 2 apparatus, apparently requires a non-described decision delay of two full cycles, and an additional sampler output line for presenting 13 (not twelve, as described) samples necessary for obtaining all the edge detection outputs needed for each "two-cycle"-based decision by the decision matrix. One implication of the non-described and largely wasteful two-cycle delay is that there are non-described storage elements required between the parallel samples and the edge detector. Fig. 5

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apparently shows a first edge being detected by $d1(t-1) \oplus d2(t-1)$ and a last edge by $d6(t) \oplus d1(t+1)$, rather than showing a convention based on using $d6(t-1) \oplus d1(t)$ and $d5(t+1) \oplus d6(t+1)$ for detecting the respective first and last edges. By applicant's convention, edge detection results using all the samples of the previous and current cycles must be held up for an edge detection that uses the first sample of the parallel twelve samples taken for the next two cycles, so that a complete set of thirteen samples needed to perform twelve edge detections is only made available to the edge detector a full two cycles after the "previous cycle" and "current cycle" samples are available. A full set of edge detections relevant to the same two cycles would be available two cycles sooner if the examiner's above-mentioned alternate convention -- using $d6(t-1) \oplus d1(t)$ and $d5(t) \oplus d6(t)$ for the first and last edge detections -- was used instead, if the sampler output is fully parallel as suggested by the disclosure.

A proposed drawing correction or corrected drawings are required in reply to the Office action to avoid abandonment of the application. The objection to the drawings will not be held in abeyance.

Specification

2. The abstract of the disclosure is objected to because the following changes are apparently necessary:

One aspect of the invention provides a novel scheme to improve channel jitter tolerance and perform data recovery across a serial data channel. In one implementation, the invention samples each data unit (cycle) in the data channel multiple times and, using two cycles, selects one of the samples as representative of the data bit or bits carried by the data unit. According to one aspect, the invention performs edge detection between adjacent data samples to

determine the location of transitions between data units (~~bits~~). A representative data sample point is chosen which is as far away as possible from the detected edge and the next expected edge and yet is also adjacent to, or equal to, the expected ideal current sample point. According to another aspect of the invention, ~~as between two equally possible samples given edges in a single cycle indicating two representative sample points~~, the algorithm selects the sample point within the current cycle which is furthest from the distribution of prior cycle edges.

Correction is required. See MPEP § 608.01(b).

3. The disclosure is objected to because of the following informalities:

The specification apparently should be amended as follows:

[0001] The invention pertains generally to serial data reception. More particularly, the invention relates to a method, apparatus, and system for extracting the correct data from a jittering data stream by using ~~over-samples~~ over-sampled data collected over two cycles.

[0002] In serial data communication systems a typical transmitting device generates pre-specified voltage levels at a particular frequency to transmit data to a receiving device over a transmission medium. A receiving device detects the voltage levels to determine the data being sent.

[0003] One common problem that affects serial communication systems is the noise and disturbances introduced into the transmitted signal. Such noise may cause jitter (a variation in the placement of data relative to the ideal location in time) and frequency offsets (a variation in the transmission frequency) which make it difficult to correctly ascertain the data transmitted.

[0004] FIG. 1 is a block diagram illustrating one embodiment of a system in which a device embodying a serial channel data recovery aspect of the invention may be employed.

[0005] FIG. 2 is a block diagram illustrating one embodiment of the serial channel data recovery aspect of the invention.

[0006] FIG. 3 is a diagram illustrating sampling of a serial data stream according to one aspect of the serial channel data recovery invention.

[0007] FIG. 4 is a matrix illustrating one embodiment of a single-cycle decision matrix used to select a data sample which is representative of a data unit ~~or bit~~.

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[0008] FIG. 5 is a matrix illustrating one embodiment of a two-cycle decision matrix used to select a data sample which is representative of a data unit ~~or bit~~ according to one embodiment of the data recovery invention.

[0009] FIG. 6 is table illustrating the selection of samples under various edge ~~transition~~ location conditions according to one embodiment of the data recovery invention.

[0010] FIGS. 7-11 illustrate various conditions under which the data recovery aspect of the invention selects a data sample based on edge ~~transition~~ location information from two data units.

[0011] FIG. 12 is flow diagram illustrating a method of practicing data recovery according to one embodiment of the invention.

[0012] In the following detailed description of the invention, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, one of ordinary skill in the art would recognize that the invention may be practiced without these specific details. In other instances well known methods, procedures, and/or components have not been described in detail so as not to unnecessarily obscure aspects of the invention.

[0013] Throughout this description the terms data unit, and cycle, ~~and/or bit~~ may ~~be~~ are used interchangeably to refer to a single data bit or other unit of data measure.

[0014] One aspect of the invention provides a data recovery algorithm which improves data extraction from a jittering and/or frequency-offset data stream by over-sampling the data stream, ~~determine~~ determining the edges ~~edge~~ edge closest to the expected ideal current sample point, and ~~select~~ selecting the actual sample point based on the previous and current data unit ~~cycle~~ samples.

[0015] FIG. 1 illustrates a block diagram of a configuration of devices in which one embodiment of the invention may be employed. A first device (transmitter) 102 transmits serial data signals to a second device (receiver) 104 over a transmission medium 106. The transmission medium may be susceptible to noise or interference which may cause jitter and/or frequency offsets in the transmitted signal. The second device includes a data recovery or sampling point error correction component 108 embodying one or more aspects of the invention to improve data extraction.

[0016] The component 108 embodying one or more aspects of the invention may include one or more integrated circuit devices, circuit boards, software media, and/or other electronic devices. The component 108 may be part of a

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communication device, network device, computing device, processing device, and/or other types of electronic devices employing some form of serial communication.

[0017] FIG. 2 is a block diagram illustrating one embodiment of the data recovery component 108 embodying one or more aspects of the invention. Clock phase over-sampling may be employed to track the incoming serial data stream and extract the correct data. According to one implementation, the data recovery system 108 includes an over-sampler 202 to receive a serial digital data stream as input and provide two or more samples (i.e., d1-d6) per signal cycle or data bit. For the exemplary embodiment shown in FIG. 2 six data samples d1-d6 serve as inputs to an edge detector 204. The edge detector 204 detects ~~edge transitions~~ edge locations between adjacent data samples. This edge information is then provided to a decision matrix component 206 which selects the best point from which to ~~determine sample~~ the data unit or bit. A selector 208 may be coupled to the over-sampler 202 to receive the sampled data; the decision matrix component 206 then causes the selector 208 to output only that sample which the decision matrix 206 selects.

[0018] FIG. 3 provides an illustration of one embodiment of an incoming serial data stream (bit0, bit1, . . . , bit5) and six samples (six times over-sampling) for each data unit, ~~bit, or cycle or bit~~ of the data stream. According to one implementation, six separate phases of a clock are used to independently sample the data stream.

[0019] Although for purposes of illustration FIG. 3 shows each data unit being sampled six times (six times over-sampling), the invention is not limited to a six time over-sampling scheme. A person of ordinary skill would appreciate that the invention may be practiced with fewer or greater number of samples per data unit. In various embodiments, a data unit may be sampled an even or odd number of times without departing from the invention.

[0020] The edge detector 204 attempts to find the ~~location~~ locations of the edges (i.e. low-to-high or high-to-low transitions) between data bits ~~bits~~ samples. In one implementation, the edge detector 204 extracts edge locations from the samples by XORing (performing exclusive OR logic operations on) ~~on~~ adjacent data samples. For the exemplary embodiment shown in FIG. 2, ~~six~~ seven samples serve as inputs to the edge detector 204 and the edge detector 204 generates six outputs, each output being obtained by XORing adjacent samples. For instance, in FIG. 3 for bit3, XORing of sample pairs d4 (between bit2 and bit3) and d5, d5 and d6, d6 and d1, d1 and d2, d2 and d3, and d3 and the next d4 (between bit3 and bit4) would provide the six outputs for the edge detector 204.

[0021] Throughout this description, the symbol \oplus is employed to refer to a

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XORing (exclusive OR) operation or any collection of operations which provide an equivalent result.

[0022] For each cycle, the edge detector 204 generates the location where the edges edge occurred between samples. For example, if data sample d3 was logic low (0), and data sample d4 was logic high (1), the edge detector 204 would indicate an edge occurred between d3 and d4.

[0023] A decision matrix component 206 is coupled to the edge detector 204 to receive the outputs from the edge detector 204 and select one of the sample points according to a predefined decision algorithm, table, or matrix.

[0024] In the absence of jitter, the data edge would consistently be detected at the same location, for example $d1 \oplus d2$. In the presence of jitter, however, over time the data edge location may move around. With a small amount of jitter, the edge may appear at two locations -- i.e. $d1 \oplus d2$ and $d2 \oplus d3$. With a larger amount of jitter, the edge may occur across at any one of four locations -- i.e. $d6 \oplus d1$, $d1 \oplus d2$, $d2 \oplus d3$, and or $d3 \oplus d4$.

[0025] FIG. 4 illustrates a single cycle decision matrix with six possible edge transition location inputs ($d1 \oplus d2$. . . $d6 \oplus d1$) for the 'next' current cycle and the ideal current state input. By locating a transition the edge and knowing the current cycle state, the 'next' state is selected.

[0026] Note that throughout this description the terms 'previous current state', and 'previously selected state', and 'previously selected sample' are used interchangeably to refer to the state or sample selected in the previous data unit cycle. The terms 'expected ideal sample', 'expected ideal sample point', 'ideal state', 'ideal current state', and 'expected ideal current sample' are used interchangeably to refer to the sample or state in the current data-unit cycle which would be selected under ideal conditions. The expected ideal sample point is the data sample or state point which would be selected if no jitter occurs between the previous and current data-unit cycles. If no jitter occurs between data-unit cycles, the expected ideal data sample would be at the same location as in the previous data-unit cycle. For example, if the currently selected current state is S1 (~~S1 was the selected state in the previous data-unit cycle~~), ~~s1~~ S1 would be selected as the next state in the current data-unit cycle under ideal conditions (no jitter).

[0027] Since FIG. 4 illustrates a single-cycle decision matrix, the closest edge information to the expected ideal sample point is not being used to determine the direction in which to shift to select the next state. For example, if the ideal current state (~~corresponding to the previous selected state~~) is S1, ~~edges an edge at that occur on d5 ⊕ d6 are used to determine~~ determines the next state S2. But

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data samples d5 and d6 are the last two samples in the current cycle (data unit) and the expected ideal sample point corresponding to ~~ideal~~ current state S1 is the first sample point in the current cycle. Because of its long distance from the expected ideal sample point S4 d1, the edge at d5⊕d6 in the current data cycle does not provide the most accurate or reliable ~~transition~~ edge from which to determine the next state.

[0028] However, the d5 and d6 samples from the previous ~~data-unit~~ cycle are located closer to the expected ideal sample ~~state or~~ point S4 d1. Hence, it would be better to use these earlier cycle samples to make a decision about the next sample point.

[0029] Because the samples d5 and d6 in the previous data cycle provide the closest edge to the expected ideal ~~state~~ S4 sample point, they provide the most accurate and reliable information about the next state.

[0030] An aspect of the invention provides a decision matrix which is tolerant to high-frequency jitter.

[0031] One aspect of the invention provides a method or algorithm to select which of the data samples is the best sample to use for extracting the correct data from the data stream. One embodiment of this method is shown in FIG. 5 illustrating a decision matrix where two data cycles, the previous and current data cycles, and the ~~previous~~ previously selected state (~~equivalent to the ideal sample point~~) are employed by the decision matrix to select the best next best state.

[0032] The decision matrix contains a single ~~ideal~~ current state variable (S1 through S6) that ~~points to~~ indicates the sample point that is currently the best sample point (expected ideal sample point). For example, a state of s1 S1 indicates that sample d1 is the best sample, s2 S2 indicates d2 is the best sample, and so on. The decision matrix uses the ~~ideal~~ current state, one of S1 through S6, and the edge locations detected in the current and previous ~~data-unit~~ cycles to determine the ~~next~~ best next state. As illustrated above, and explained in more detail below, the decision matrix seeks to determine the ~~next~~ best next state ~~by selecting based on the closest transition edge to the expected ideal current state sample point~~ from among the current and previous data cycles. Decision matrixes employing both the current and previous cycles improve jitter tolerance of an incoming serial data stream.

[0033] As illustrated in FIG. 5, for each of the six ~~ideal~~ current states there are five edges edge locations that are used to determine what the next state will be. For examples, if the current state is S6, then the edges generated by the previous cycle samples d4⊕d5, d5⊕d6, by the previous cycle sample and current

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cycle sample and $d6 \oplus d1$, and by the current cycle samples $d1 \oplus d2$ and $d2 \oplus d3$ will be used to determine the next state.

[0034] Referring to FIG. 6, if no edge is detected on any of these five edges edge locations then no state change is made; ~~the next state is the ideal state (equivalent to the previously selected state)~~. If a single edge is detected on one of these five edges edge locations, then the next state is determined by that edge. If more than one edge is detected on more than one of these five edges edge locations and they all generate indicate the same next state, then that next state will be used. Finally, if more than one edge is detected on more than one of these five edges edge locations and the next state generated indicated by these edges are different, then there is a conflict and the next state will be the same as the ideal current state (~~equivalent to the previously selected state in the previous data unit cycle~~).

[0035] According to another implementation, if more than one edge is detected and different states are generated indicated, then the state which was generated indicated by the most number of edges is selected as the next state. For example, if two edges generate indicate state $s1$ S1 and one edge generates indicates $s2$ S2, then the next state will be $s1$ S1.

[0036] In more detail, referring to FIG. 7, if the ~~ideal~~ current state or sample is $S6$ and $d5 \oplus d6$ is true (an edge ~~transition~~ was detected) but no other edges were detected, then the next state is $s1$ S1. Similarly, referring to FIG. 8, if the ~~ideal~~ current state is $S6$ and $d2 \oplus d3$ is true and no other edges were detected, then the next state is $s5$ S5. Also, if the ~~ideal~~ current state is $S6$ and both $d2 \oplus d3$ and $d1 \oplus d2$ are true, the next state is $s5$ S5. However, if the ~~ideal~~ current state is $S6$ and both $d5 \oplus d6$ and $d2 \oplus d3$ are true, then there is a conflict and the next state will stay at $s6$ S6.

[0037] Thus far, the next state has been selected from among the two states adjacent to the ~~ideal~~ current state or the ~~ideal~~ current state itself. For example, if the ~~ideal~~ current state is $S2$, then the next state will be either $s1$ S1, $s2$ S2, or $s3$ S3 as determined by the matrix. Additionally, a study of the exemplary matrix in FIG. 5 discloses that the next state is chosen to have the location of its expected ideal sample point be as far as possible from the detected edge and the next expected edge and yet also adjacent to, or equal to, the ~~ideal~~ location of the expected ideal sample point for the current state. That is, the decision matrix is coded so that the state pointer to next state moves away from the selecting representative data samples that are close to an edge. A ~~state~~ or sample point is selected which lies substantially midway (or moves in the direction of the mid-point) between the detected edge and the next expected edge and yet is also adjacent to, or equal to, the location of the expected ideal sample point for the ~~ideal~~ current state. Note that for a system which samples

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each data unit (bit) N times (where N is an integer value), the next edge is expected to lie a distance of N samples from the detected edge. In the examples of FIGS. 7 & 8 the value of N is six since each data unit is sampled six times, at different locations or points.

[0038] For example, referring to FIG. 9, if the ~~ideal~~ current state is S2 and the only edge detected is at d5⊕d6 (either in the previous cycle or next cycle), then, state ~~s2~~ S2 is selected since it d2 lies at the midpoint between the two edges (previous d5 and current d5). Note that in this example, the edge is assumed to lie at d5; since d2 is equidistant between two d5 samples, ~~s2~~ d2 is selected as the best ~~state or sample~~. Similarly, referring to FIG. 10, if the ~~ideal~~ current state or sample is S2 and the only edge detected is at d6⊕d1 or d1⊕d2, then the next state or sample is selected to be ~~s3~~ S3 since it d3 is the furthest ~~state or sample~~ from ~~s6~~ d6 or ~~s4~~ d1, respectively, yet adjacent to ~~s2~~ d2. Also, referring to FIG. 11, if the ~~ideal~~ current state or sample is S2 and the only edge detected is at d3⊕d4 or d4⊕d5, then the next state or sample is selected to be ~~s4~~ S1 since it d1 is the ~~further~~ furthest state from ~~s3~~ d3 or ~~s4~~ d4, respectively, yet and is adjacent to the expected ideal current state ~~S2~~ sample point d2.

[0039] A person of ordinary skill in the art would recognize that decision matrixes for any number of states may be created as described above.

[0040] A conditional state occurs ~~where~~ where two states are equally likely under the algorithm described above. For example, if the ~~ideal~~ current state is S2 and d2⊕d3 is the only edge, then ~~s3~~ S3 and ~~s4~~ S1 are equally likely. According to one implementation, one of the two possible states is chosen arbitrarily when this condition occurs.

[0041] Another aspect of the invention provides a method, system, or algorithm to decide between two equally likely states. That is, where a conditional state occurs (i.e., where both ~~s4~~ S1 and ~~s3~~ S3 are equally likely) then the decision matrix looks at the distribution of previous edges to select the best next state from among the two choices. ~~As between~~ Given two possible next states, the algorithm selects the state with an expected ideal sample location that which is furthest from the distribution of prior cycle edges.

[0042] For example, in a low jitter channel edges may occur only on d1⊕d2 and d2⊕d3. Based on the decision matrix in FIG. 5, with edges only at d1⊕d2 and d2⊕d3 the state pointer will converge and alternate between ~~s4~~ S4 and ~~s5~~ S5. Assuming the incoming jitter increases, transitions may now occur across four edge locations, i.e. d6⊕d1, d1⊕d2, d2⊕d3, and d3⊕d4. If at least three d6⊕d1 edges in a row occur, the state pointer either will move from ~~s4~~ S4 to ~~s3~~ S3 or from ~~s5~~ S5 to ~~s4~~ S4 and then to ~~s3~~ S3 (~~depending on whether it started in s5 or s4~~). In either case the current state pointer will be S3 and the previous

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state will be S4. With the current state of S3, if the next edge detected is d3⊕d4 then the next state is either s2 S2 or s4 S4. However, it is undesirable to select s2 S2 because data sample d2 is ~~right in the middle of~~ centrally overlapped by the distribution of edges -- recent edges were on d6⊕d1, d1⊕d2, d2⊕d3, and d3⊕d4. The fact that d2 is ~~located in the middle of~~ centrally overlapped by the distribution of recent previous edges (or ~~within the distribution of previous edges~~) increases the likelihood that s2 S2 may be an erroneous reading. Rather, an algorithm of the invention would select s4 S4 as the next state in this case. State s4 S4 is more desirable than s2 S2 because data sample d4 ~~is on~~ overlaps the far right-hand edge end of the distribution of recent edges and is more likely to have the correct data. According to one implementation, state s4 S4 would be selected since the previous state was s4 S4. That is, as ~~between~~ given two possible states (i.e., s2 S2 or s4 S4) the algorithm would select the state which was most recently selected in previous data cycles. In the example above, previous states would include S5, S4, and S3, from earliest to most recent, in that order. As Given a choice between states s2 S2 and s4 S4, state s4 S4 was most recently selected so it would be selected in this case.

[0043] In another example, if a transition is detected at d1⊕d2 in (current state S1) the two possible states are s2 S2 or s6 S6. If the previous states include, from earliest to most recent, S3, S2, S1, S6, and S1, then s6 S6 would be selected as the best next ~~best~~ state or ~~sample~~ since, as with the choice between S2 and S6, S6 was the most recently selected state.

[0044] Thus, where a choice must be made between two possible states, the invention selects the most recent state to have been selected from among the two possible states or, equivalently, select selects the state with an expected ideal sample point located ~~furthest from~~ closest to the midpoints between the most recent previous edges (or the distribution of previous edges). Such a selection algorithm has shown to increase jitter tolerance of an incoming serial data stream. In one implementation, the invention may retain memory of the previous M selected states so that a decision between two possible states may be made. In various implementations, the number of previous edges employed to make such decision may vary.

[0045] FIG. 12 illustrates one method of practicing the data recovery aspect of the invention. Each data unit (bit) across a serial data channel is sampled multiple times, at different locations along its cycle 1202. These samples are then employed to determine edge transitions locations between adjacent data samples 1204. One of the data samples is then selected as representative of a data unit based on the edge ~~transition~~ information for two data units/cycles (i.e. the current data cycle and the previous data cycle) 1206.

[0046] According to one implementation, the serial data stream received by a

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device embodying the invention may be a Universal Serial Bus (USB) compliant data stream, a Serial Advanced Technology Attachment (ATA) compliant data stream, and/or many other types of serial communication channels.

[0047] A person of ordinary skill in the art would recognize that there are other benefits to the invention herein disclosed. For example, while some data recovery systems may gather edge information over five (5) cycles and perform a histogram of this data to determine an optimal sample point, such architecture must store much more information than the disclosed approach. Because the invention need not store as much information as other data recovery systems, it can be implemented in a smaller area of silicon (in a chip) since less transistors are employed.

[0048] Greater or fewer sampling points may be employed in different embodiments without deviating from the invention. Although some exemplary embodiments of the invention have employed six-times (6 x) over-sampling for purposes of illustration, the disclosed invention may be implemented at any other level of over-sampling without deviating from the invention.

[0049] While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that this invention not be limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those ordinarily skilled in the art. Additionally, it is possible to implement the invention or some of its features in hardware, programmable devices, firmware, software or a combination thereof. The invention or parts of the invention may also be embodied in a processor readable storage medium or machine-readable medium such as a magnetic, optical, or semiconductor storage medium.

Appropriate correction is required.

Claim Rejections - 35 USC § 112

4. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

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5. Claims 1-33 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

The claims apparently should be amended as follows:

1. A method comprising:
receiving a serial data stream;
sampling each data unit in the data stream N times to obtain multiple data samples per data unit;
detecting ~~edge transitions~~ edges between adjacent data samples; and
selecting a ~~first current~~ data sample, from among the multiple data samples and representative of the current data unit, based on the location of ~~edge transitions~~ edges over the current and previous data ~~cycles~~ units and on the location of an expected ideal data sample, to perform data recovery.
2. The method of claim 1 wherein the selected ~~first current~~ data sample location is determined by the edge ~~transition~~ location in the previous or current data ~~cycles~~ units which is closest to the expected ideal data sample location.
3. The method of claim 1 wherein the N samples per data unit are taken at different locations along the cycle of each data unit.
4. The method of claim 1 wherein the expected ideal data sample is within the current data unit ~~cycle~~ and a distance of N samples from the previously selected data sample.
5. The method of claim 1 wherein selecting the current data sample includes, selecting the ~~first current~~ data sample to lie ~~in the direction of~~ substantially at or near the mid-point between the detected edge ~~transition~~ and the next expected edge ~~transition~~ and at a distance of N-1, N, or N+1 samples from the previously selected data sample, ~~whichever is closest to the mid-point~~.
6. The method of claim 1 wherein selecting the ~~first current~~ data sample based on the location of ~~edge transitions~~ edges over the current and previous data ~~unit~~ cycles units includes selecting a data sample based on 2*N consecutive data samples across the current data unit ~~cycle~~ and the previous data unit ~~cycle~~.
7. The method of claim 1 wherein if no ~~edge transitions~~ edges are detected the selected ~~first current~~ data sample location is the expected ideal data sample location.

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8. The method of claim 1 wherein if only one edge ~~transition~~ is detected, that edge ~~transition~~ determines the selected first current data sample location.
9. The method of claim 1 wherein if multiple ~~edge-transitions~~ edges are detected and all ~~correspond to~~ indicate the same data sample location, then that data sample location is selected as the first current data sample location.
10. The method of claim 1 wherein if multiple data ~~edge-transitions~~ edges are detected and they ~~correspond to~~ indicate different data samples sample locations, then the selected first current data sample location is the expected ideal data sample location.
11. The method of claim 1 further comprising: maintaining a list of the M previous selected data ~~samples~~ sample locations, where M is an integer value.
12. The method of claim 1 wherein in selecting the first current data sample, as ~~between given~~ two equally likely data sample locations, the data sample location most recently selected in previous ~~cycles~~ data units is chosen.
13. An apparatus comprising:
 - a sampling device to sample data units of a serial data stream N times at different points in each data unit, where N is an integer value;
 - an edge detector coupled to the sampling device to detect ~~edge-transitions~~ edges between consecutive data samples; and
 - a selection controller coupled to the edge detector to receive the detected ~~edge-transitions~~ edges from the edge detector and select a data sample to represent the current data unit according a predefined decision algorithm for data sample timing correction employing the current and previous data ~~unit-cycles~~ units and the expected ideal current data sample location.
14. The apparatus of claim 13 wherein the expected ideal current data sample is located within the current data unit ~~cycle~~ and at a distance of N samples from a previously selected ~~second~~ data sample in the previous data unit ~~cycle~~.
15. The apparatus of claim 13 wherein the value of N is six.
16. The apparatus of claim 13 wherein the selection controller selects the first current data sample based on a ~~first an edge transition for either in~~ the previous or current data ~~cycles~~ units, whichever edge ~~transition~~ is closest to the expected ideal current data sample location.
17. The apparatus of claim 13 wherein the selection controller selects the

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~~first current~~ data sample to lie ~~in the direction of~~ substantially at or nearer to the mid-point between a detected ~~first edge transition~~ and a next expected edge transition and also at a distance of -1, 0, or +1 samples from the expected ideal data sample location, ~~whichever is closest to the mid-point.~~

18. The apparatus of claim 13 wherein if no ~~edge transitions~~ edges are detected by the edge detector, the selection controller selects the expected ideal data sample location to obtain the first current data sample.

19. The apparatus of claim 13 wherein if only one edge transition is detected by the edge detector then the selection controller selects the ~~first~~ data sample position which lies ~~in the direction of~~ substantially at or nearer to the mid-point between the detected edge transition and the next expected edge transition and also at a distance of -1, 0, or +1 samples from the expected ideal data sample location, ~~whichever is closest to the mid-point.~~

20. The apparatus of claim 13 wherein if multiple ~~edge transitions~~ edges are detected by the edge detector and all ~~transitions~~ edges ~~correspond to~~ indicate the same ~~first~~ data sample location, then the selection controller selects that ~~first~~ data sample location as the next expected ideal data sample location.

21. The apparatus of claim 13 wherein if multiple data ~~edge transitions~~ edges are detected by the edge detector and they ~~correspond to~~ indicate different data samples sample locations, then the selection controller selects the ~~first data sample to correspond with~~ the expected ideal data sample location.

22. The apparatus of claim 13 further comprising: a storage device to maintaining a list of the M previous selected data ~~samples~~ sample locations, where M is an integer value.

23. The apparatus of claim 13 wherein, ~~as between~~ given two equally likely data sample locations, the selection controller selects the ~~first~~ data sample location that was most recently selected in previous cycles.

24. A machine-readable medium having one or more instructions to perform data recovery, which when executed by a processor, causes the processor to perform operations comprising:

- sampling each data unit in a data stream N times, where N is an integer value, at different locations along each data unit, to obtain multiple data samples per data unit;

- detecting ~~edge transitions~~ edges between adjacent data samples; and
- selecting a first current data sample representative of the current data unit based on the location of ~~edge transitions~~ edges over the previous and current

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data units and the location of an expected ideal current data sample to perform data recovery.

25. The machine-readable medium of claim 24 wherein the representative data sample is selected to lie ~~in the direction of~~ substantially at or nearer to the mid-point between the detected edge and the next expected edge and ~~yet also~~ adjacent to, or equal to, the expected ideal current data sample location within the current data unit cycle.

26. The machine-readable medium of claim 24 wherein if no ~~edge transitions~~ edges are detected the selected first current data sample ~~corresponds to~~ has the same location as the expected ideal current data sample.

27. The machine-readable medium of claim 24 wherein if only one edge ~~transition~~ is detected, then that edge ~~transition~~ determines the selected first current data sample to be a sample which lies ~~in the direction of~~ substantially at or nearer to the mid-point between the detected edge ~~transition~~ and a next expected edge ~~transition~~ and at a distance of -1, 0, or +1 samples from the expected ideal current data sample location, ~~whichever is closest to the mid-point.~~

28. The machine-readable medium of claim 24 wherein if multiple edge ~~transitions~~ edges are detected and all ~~correspond to~~ indicate the same data sample location, then that data sample location is selected as the first current data sample location.

29. The machine-readable medium of claim 24 wherein if multiple data edge ~~transitions~~ edges are detected and they ~~correspond to~~ indicate different edge ~~transitions~~ data sample locations then the selected first current data sample is at the same location as the expected ideal current data sample.

30. The machine-readable medium of claim 24 wherein selecting the first current data sample, ~~as between given~~ two equally likely data sample locations, the data sample location most recently selected in previous cycles is chosen as the first current data sample location.

31. An apparatus comprising:

a sampling means for sampling data units of a serial data stream N times at different points in each data unit, where N is an integer value;

an edge detecting means coupled to the sampling means, the edge detecting means for detecting ~~edge transitions~~ edges between consecutive data ~~unit~~ samples; and

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a selection means coupled to the edge detector, the selection means for receiving the detected ~~edge transitions~~ edges from the edge detector ~~detecting means~~ and select a ~~first~~ current data sample to represent a current data unit.

32. The apparatus of claim 31 wherein the ~~first~~ current data sample is located within a current data unit ~~cycle~~ and at a distance of N-1 to N+1 samples from a previously selected ~~second~~ data sample in a previous data unit ~~cycle~~.

33. The apparatus of claim 31 wherein the selection means selects the ~~first~~ current data sample based on a ~~first~~ an edge transition for either the previous or current data ~~eyeles~~ units, whichever edge transition is closest to an expected ideal current data sample.

Claim Rejections - 35 USC § 102

6. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

7. Claims 1-23 and 31-33 are rejected under 35 U.S.C. 102(b) as being anticipated by U.S. Patent No. 5,598,446 to Van Der Tuijn (hereafter referred to as Van Der Tuijn).

Van Der Tuijn discloses clock signal extraction arrangements for sampling a signal from, e.g. a cordless telephone, thereby “receiving a serial data stream”. Received digital data is oversampled (col. 20, line 64-67) in Van Der Tuijn’s preferred embodiment. In one embodiment disclosed by Van Der Tuijn (col. 4, lines 55-56), “N” = 6-times oversampling is used for “sampling each data unit in the data stream N times to obtain multiple data samples per data unit”. Edges between adjacent samples in Van Der Tuijn’s arrangements are detected (col. 2, lines 52-55) in the oversampled data by an edge detector 41. A sample is selected by the extracted clock (col. 4, lines

61-67) in Van Der Tuijn's arrangements. In Van Der Tuijn's preferred embodiment, the phase of the extracted clock signal is varied based on the center between each pair of consecutive edges. Variations in the positions of a number of centers are averaged to produce a phase error. In Van Der Tuijn's preferred embodiment the current center and an immediately previous center are used to produce the phase error, and the phase of the extracted clock signal is changed an amount equal to the phase error (col. 1, lines 42-57). Accordingly, Van Der Tuijn's sample selection is "based on the location of edge transitions over the current and previous data cycles". With Van Der Tuijn's arrangements, the center between each pair of consecutive edges is determined by counting a number of cycles of an oversampling signal which occur between each pair of consecutive edges to obtain a bit width. The bit width is divided in half and the result added to an edge phase value to obtain a value for the center. Accordingly, Van Der Tuijn's sample selection is also based on "the location of an ideal data sample".

Regarding claims 2 and 16, as the edges preceding and following the center are considered in Van Der Tuijn's sample selection, the "closest" edges determine the center and thus determine the "ideal data sample".

Regarding claims 4 and 14, ideally, there is no jitter, the centers do not move and so maintain an "N" sample spacing.

Regarding claims 5, 17, 19 and 32, when the correction window in Van Der Tuijn's arrangements is one (col. 7, lines 9-15), the representative sample timing can only shift by one sample position among the oversampled data from one cycle to the next.

Regarding claim 6, as mentioned above with regard to phase error determination in Van Der Tuijn's arrangements, sample selection can be based on the most recent two cycles of oversampled data.

Regarding claims 7 and 18, with Van Der Tuijn's arrangements, a pair of missing edges would apparently result in no change to the selected sample timing, resulting in no change from the "ideal" representative sample position for the cycle.

Regarding claims 8, 19 and 33, with Van Der Tuijn's arrangements, a missing edge at the end of a cycle would apparently result in no change to the selected sample timing, which would be referenced from the leading edge of a previous cycle.

Regarding claims 9, 10, 20 and 21, detecting regularly-spaced "multiple edge transitions" with Van Der Tuijn's arrangements, *i.e.* regularly-spaced starting and ending edges for multiple data units, results in regularly spaced and centered representative samples.

Regarding claims 12 and 23, when the bit width is an even number of samples, there are two samples that are equally centered within the bit width, and the earlier of the two is apparently preferred by Van Der Tuijn's arrangements (see *e.g.* interval "BIT 2", Fig. 4).

Claim Rejections - 35 USC § 103

8. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the

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invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

9. Claims 24-30 are rejected under 35 U.S.C. 103(a) as being unpatentable over Van Der Tuijn.

Van Der Tuijn does not disclose using software instructions to implement the logic operations described for his sample selection arrangements. Official Notice is given that the advantages of implementing logic operations by using a programmed computer, including low cost, ease of distribution and modification, hardware development design emulation/simulation, etc., were well known at the time the invention was made. It would have been obvious to a person having ordinary skill in the art at the time the invention was made to implement Van Der Tuijn's logic operations using a programmed computer. Such an implementation would have been obvious because the advantages of implementing logic operations by using a programmed computer, including low cost, ease of distribution and modification, hardware development design emulation/simulation, etc., were already well known.

Conclusion

10. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Stephen M. Baker whose telephone number is (703) 305-9681. The examiner can normally be reached on Monday-Friday (11:00 AM - 7:30 PM).

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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Albert DeCady can be reached on (703) 305-9595. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).



Stephen M. Baker
Primary Examiner
Art Unit 2133

smb